NASA Phase I Project Summary

Nonproprietary

Firm: Creare Incorporated
Contract Number: NNX13CC30P
Project Title: A Reliable, Efficient Cryogenic Propellant Mixing Pump With No Moving Parts

Identification and Significance of Innovation:

Refueling spacecraft in space offers tremendous benefits for increased spacecraft payload capacity and reduced launch cost. However, there are several key challenges with space refueling associated with the storage and handling of liquid cryogens in space. To meet these challenges, we propose to develop a reliable, compact, efficient cryogenic mixing pump with no moving parts. The mixing pump will prevent thermal stratification of the cryogen and simplify pressure control for storage tanks. The mixing pump uses an innovative thermodynamic process to generate fluid jets to promote fluid mixing, eliminating the need for mechanical pumps. Our innovative mechanism will be able to self-prime and generate a high-pressure rise. The device will significantly enhance the reliability of pressure control systems for storage tanks.

Technical Objectives and Work Plan:

The overall technical objective is to develop a highly reliable, efficient cryogenic mixing pump that will enable reliable pressure control for cryogenic storage tanks. In Phase I, we assembled a proof-of-concept pump and demonstrated its pumping performance with two-phase flow at room temperature. We then developed an advanced configuration for the Phase II laboratory cryogenic pump. We developed an analytical model to optimize key design parameters of the pump, and predict its head-flow curves and efficiency under different inlet conditions.

Technical Accomplishments:

In Phase I, we successfully built and demonstrated a proof-of-concept two-phase pump intended for room temperature operation. Our test apparatus included a variety of instrumentation and flow visualization capability. The Phase I tests allowed us to gain significant operating experience and insight into the operation of a two-phase pump. Our test results show that the small proof-of-concept two-phase pump achieves a relatively high flow rate and a maximum pressure rise of 1.4 psi. We developed an analysis model to determine the operating parameters and to estimate the flow resistances inside the pumping chamber, the pumping flow rate, pump head, and power input to the pump. Finally, based on the operating experience gained and lessons learned in Phase I, and results from our analysis model, we developed a preliminary layout design for the Phase II prototype two-phase pump. We also developed a preliminary design of a highly efficient power supply for the pump. Our design shows that the pump can achieve an overall efficiency of 45%, significantly higher than conventional cryogenic pumps. All technical objectives were successfully completed, and the results prove the feasibility of the proposed concept.

NASA Application(s):

The technology developed in this project will enable reliable long-term and short-term cryogenic propellant storage in space for refueling. The mixing pump will enable effective pressure control for cryogenic tanks by maintaining a uniform fluid temperature. Its high reliability will significantly enhance the effectiveness of the pressure control mechanism. The device developed in this project can also be used as a two-phase cryogenic pump with no impellers or pistons to enable reliable cryogen transfer for space applications. The technology also has application in low-G propellant liquid mass gauging by serving as a reliable compression mass gauge.

Non-NASA Commercial Application(s):

The technology developed in this project has applications in reliable two-phase pumps for cryogenic fluids and refrigerant flows. Applications include cryogenic two-phase cooling systems for superconductors. The technology also has applications in thermal management systems for advanced electronics and photonics systems, as well as advanced environmental control systems for future military vehicles.

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